LONDON-WEST MIDLANDS ENVIRONMENTAL STATEMENT

Volume 5 | Technical Appendices

CFA17 | Offchurch and Cubbington

Flood risk assessment (WR-003-017)

Water resources

November 2013

VOL 5

ES 3.5.2.17.14

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Department for Transport

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Appendix WR-004-017

Environmental topic:	Water resources and flood risk assessment	WR
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List of Acronyms

A full list of acronyms and terms will be compiled for the draft and final Environmental Statement (ES), those listed below are used within this document:

CC	Climate Change
CoCP	Code of Construction Practice
DAS	Design Approach Statement
DTM	Digital Terrain Model
EIA	Environmental Impact Assessment
ES	Environmental Statement
FEH	Flood Estimation Handbook
FMfSW	Flood Map for Surface Water
FRA	Flood Risk Assessment
HS2	High Speed 2
IH124	Institute of Hydrology Report No 124
LEMP	Local Environmental Management Plan
LiDAR	Light Detection and Ranging
LWM	London West Midlands
MPAT	Mid Point Autotransformer Substation
NPPF	National Planning Policy Framework
OS	Ordnance Survey
PFRA	Preliminary Flood Risk Assessment
ReFH	Revitalised Flood Hydrograph
SFRA	Strategic Flood Risk Assessment
SMR	Scope and Methodology Report
SuDS	Sustainable Drainage Systems
2D	Two dimensional

1 Introduction

1.1 Structure of the water resources and flood risk assessment appendices

1.1.1 The water resources and flood risk assessment (FRA) appendices comprise of four parts. The first of these is a route-wide appendix (Appendix WR-001-000).

1.1.2 Three specific appendices for each community forum area (CFA) are also provided. For the Offchurch and Cubbington area (CFA17) these are:

- a water resources assessment (Appendix WR-002-017);
- a FRA (i.e. this appendix); and
- a hydraulic modelling report (Appendix WR-004-010).

1.1.3 Maps referred to throughout the water resources and FRA appendices are contained in the Volume 5 water resources map book.

1.2 Scope of this assessment

1.2.1 This FRA considers the assessment of flood risk in this study area, which is defined as the area within 1km of the route within CFA17. The assessment has been carried out in accordance with the requirements of the National Planning Policy Framework (NPPF)[1], which aims to prevent inappropriate development in areas at risk of flooding and to ensure that, where development is necessary in areas at risk of flooding, it is safe without increasing flood risk elsewhere.

1.2.2 This FRA presents baseline (current day) flood risk and post-construction flood risk as a result of the Proposed Scheme and has been written to demonstrate the relative change in flood risk as a result of the Proposed Scheme. Whilst all change in risk status is highlighted, the focus of the document is on the change in risk status to local receptors, particularly existing infrastructure.

1.2.3 A risk-based methodology has been adopted through the application of the source-pathway-receptor model. This model has been used to identify the cause of 'sources' of flooding to and from a development. The identification is based on a review of local conditions and consideration of the effects of climate change.

1.2.4 In order for there to be a flood risk, all the elements of the model (a flood source, a pathway and a receptor) must be present. Furthermore, effective mitigation can be provided by removing one element of the model, for example by removing the pathway or receptor.

1.2.5 Receptors may include people and their properties, business and infrastructure, and the built and natural environment within the range of the flood source which are connected to the source of flooding by a pathway.

[1] Department for Communities and Local Government (2012) *National Planning Policy Framework*

1.2.6 This FRA has been completed to inform the Environmental Statement (ES) for the works, which will be a key part of the HS2 hybrid Bill submission required for the Proposed Scheme. The hybrid Bill is necessary for powers to build the railway, powers to buy land and for planning consent.

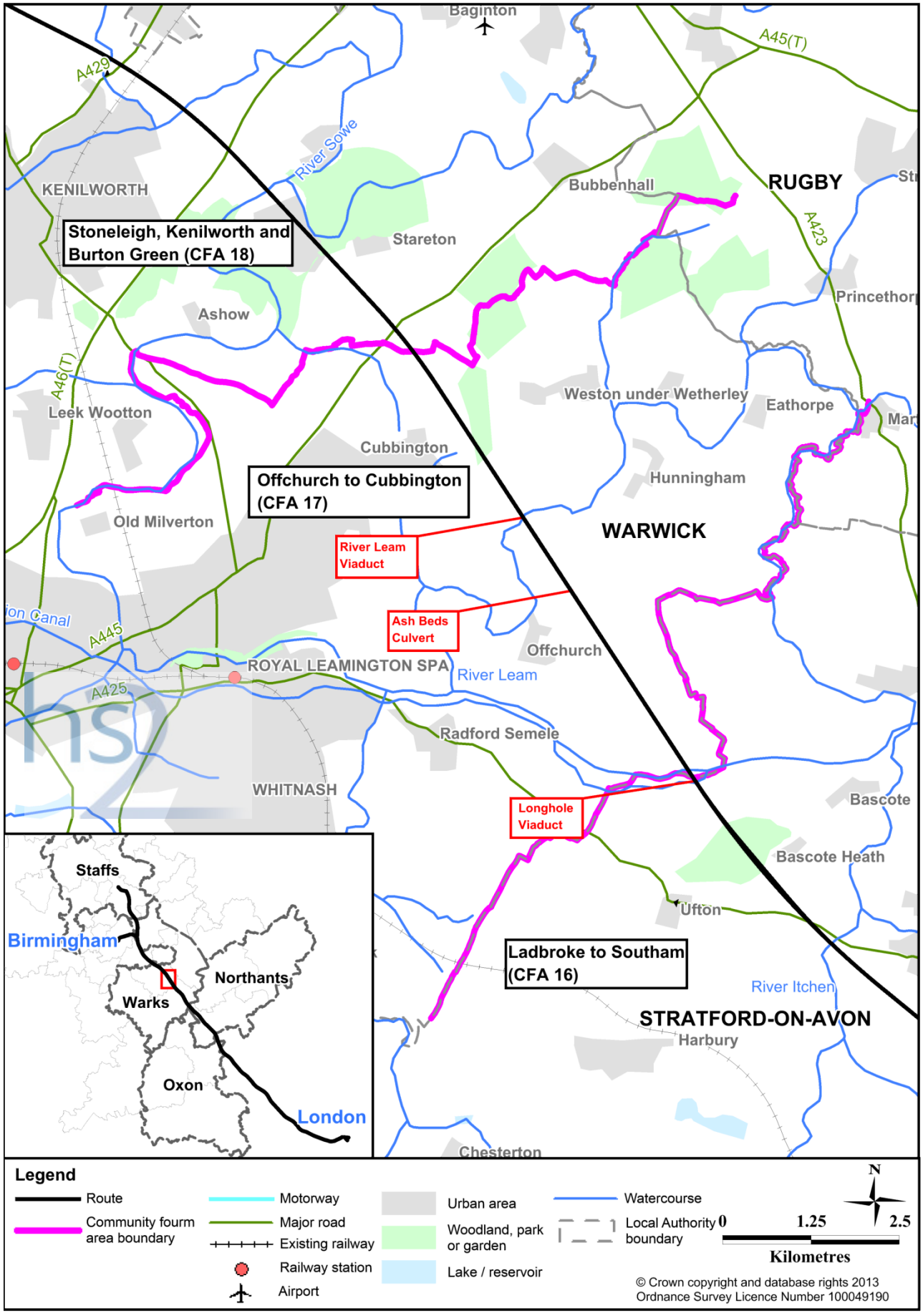
1.2.7 The Proposed Scheme will cross four surface water features within this study area, which are the River Leam, two of its tributaries and the Grand Union Canal.

1.3 Location

1.3.1 In this FRA the study area covers a 7.3km section of the Proposed Scheme in the Warwick District, where it passes to the east of Royal Leamington Spa. It extends from the Grand Union Canal in the south to the CFA boundary between Weston-under-Wetherley and Stoneleigh in the north. The area includes land within the parishes of Offchurch, Cubbington and Weston-under-Wetherley.

1.3.2 A location plan of the Proposed Scheme within this study area is shown on Figure 1.

Figure 1: Location plan



2 Flood risk assessment methodology

2.1 Source-pathway-receptor model

2.1.1 Flood risk is assessed using the source-pathway-receptor model. In this model, individual sources of flooding within the study area are identified. The primary source of flooding is rainfall, which is a direct source in the short term (surface water flooding) and can lead to flooding from watercourses (river flooding) and overloaded man-made collection systems (sewers) in the short or medium term. Stored rainfall, whether naturally, in aquifers (groundwater) and natural lakes, or artificially in impounded reservoirs and canals can lead to flooding when the storage capacity of the system is exceeded.

2.1.2 A final source of flooding arises from tidal effects and storm surges caused by low pressure systems over the sea. However given the inland location of this study area, this final source of flooding does not pose a risk.

2.1.3 For there to be a risk of flooding at an individual receptor there must be a pathway linking it to the source of flooding. The pathways within the study area are assessed by reviewing national datasets that show the spatial distribution of flood risk. The associated risk magnitude is then categorised.

2.1.4 In general, receptors considered in this assessment include the Proposed Scheme and existing development within 1km of the route. However any receptors beyond this where a significant impact was expected were considered in this assessment. The Proposed Scheme includes all associated temporary and permanent infrastructure. Areas of interest are identified through comparison of the national spatial datasets with the design drawings. Where a risk is identified, mitigation is required as part of the design to prevent an increase in flood risk in line with recommendations in the NPPF.

2.1.5 The vulnerability of each receptor is classified using Table 2 of the NPPF Technical Guidance Document[2].

2.1.6 The assessment then considers the vulnerability of the receptor with reference to the flood risk category of the source using Table 3 of the NPPF Technical Guidance Document and assesses whether the scheme has any potential to influence or alter the risk of flooding to each receptor. The Proposed Scheme will ensure that there is no adverse effect on the risk of flooding to third party receptors, and therefore, where such potential exists, mitigation is proposed based on further analysis.

2.1.7 The FRA defines the baseline flood risk and vulnerability of receptors. This is used to define the value, importance and significance of effects which is provided within the ES.

[2] Department for Communities and Local Government (2012) *National Planning Policy Framework Technical Guidance*.

2.2 Flood risk categories

2.2.1 The level of flood risk is categorised by assessing the design elements against the datasets for each source. A matrix showing the flood risk category associated with each flooding source is presented in Table 1.

Table 1: Flood risk category matrix for all flooding sources

Source of flooding	Flood risk category				
	No risk	**Low**	**Medium**	**High**	**Very high**
Watercourse[3]		Flood Zone 1	Flood Zone 2	Flood Zone 3a	Flood Zone 3b
Surface water/ overland flow[4]	No FMfSW	FMfSW <0.3m for 1 in 200 year event	FMfSW >0.3m for 1 in 200 year event and FMfSW <0.3m for 1 in 30 year event	FMfSW >0.3m for 1 in 30 year event	
Groundwater[5]		Very low-low	Moderate	High-very high	
Drainage and sewer systems[6]	No sewer in vicinity of site	Surcharge point >20m from site and no pathways	Surcharge point within 20m of site and restricted pathways	Sewer network crosses site and pathways exist	
Artificial sources[7]	Outside of inundation mapping/no pathway exists	Within inundation mapping/pathway exists			

2.3 National planning policy framework

2.3.1 This assessment of flood risk makes use of the NPPF[1] which is the Government's planning policy in relation to development and flood risk. It is set out within the NPPF that inappropriate development in areas at risk of flooding should be avoided by directing development away from areas at highest risk, but where development is necessary, making it safe without increasing flood risk elsewhere. The NPPF requires that proposed development located within Flood Zones 2 and 3 is assessed in relation to flood risk. This includes both flood risk to the development and any increases in flood risk elsewhere as a result of the development, with an allowance for climate change.

2.3.2 Methods used to ensure that development is at the lowest possible risk and that the development is safe without causing an increased risk elsewhere includes the application of the Sequential and Exception Tests. However, the Sequential Test has been considered as part of the overview FRA for the Proposed Scheme presented in Volume 3 of the ES and hence has not been repeated in this FRA.

[3] River flood risk taken from the Environment Agency Flood Zone mapping or hydraulic modelling carried for this FRA.
[4] Surface water flood risk taken from the Environment Agency Flood Maps for Surface Water (FMfSW).
[5] Groundwater flood risk taken from local flood risk assessment reports.
[6] Identified using the Severn Trent Water's assets network.
[7] Risk from reservoir flooding identified using the Environment Agency Reservoir Inundation mapping, canal flooding taken from identifying proximity of the Proposed Scheme to canals from Ordnance Survey mapping.

Flood zone classification

2.3.3 The NPPF splits the Environment Agency's Flood Map into three separate Flood Zones. These Flood Zones should be used in determining the appropriateness of proposed development uses and they represent flooding without flood defences in place.

2.3.4 The Flood Zones are defined as:

- Flood Zone 1 – areas with a 'low probability' of flooding and where the annual probability of flooding is lower than 0.1% for either river or sea flooding. The NPPF imposes no constraints upon the type of development within Flood Zone 1;
- Flood Zone 2 – areas with a 'medium probability' of flooding and where the annual probability of flooding is between 0.1 and 1.0% for river flooding or between 0.5 and 0.1% for sea flooding. The NPPF recommends that Flood Zone 2 is suitable for most types of development with the exception of 'highly vulnerable' land uses; and
- Flood Zone 3 – areas with a 'high probability' of flooding and where the annual probability of flooding is 1.0% or greater for river flooding or 0.5% or greater for sea flooding. The NPPF recommends that appropriate development is based upon a further classification of Flood Zone 3: 3a high probability and 3b functional floodplain (where water has to flow or be stored in times of flood).

2.4 Local flooding planning policy documents

2.4.1 The local policies for this study area with implications in relation to flood risk are:

- Warwick District Local Plan 2007[8] – DP1 Layout and Design. Policy DP1 requires that the necessary drainage from the development in incorporated, without causing unacceptable harm to retained features; and
- Warwick District Local Plan 2007 – DP11 Drainage. Policy DP11 encourages the development to incorporate sustainable drainage systems. Where this is not proposed the reasons why must be fully demonstrated.

2.4.2 The Warwick District Strategic Flood Risk Assessment (SFRA)[9] and the Warwickshire Preliminary Flood Risk Assessment (PFRA)[10] aid the Councils in preparing sustainable policies for the long-term management of flood risk and improving existing emergency planning procedures. The SFRA is used as an evidence base to promote the location of future development primarily in low flood risk areas. This SFRA has been used to inform this FRA.

2.5 Historical sources of flooding

2.5.1 The historical sources of flooding which have occurred, either at the location of the route or in close proximity, have been determined as part of this FRA. These areas of

[8] Warwick District Council (2007). *Warwick District Plan*.
[9] Warwick District Council (2013). *Warwick Level 1 Strategic Flood Risk Assessment. Volume 1* Produced by Mouchel.
[10] Warwickshire County Council (2011). *Warwickshire Preliminary Flood Risk Assessment*. Completed by Royal Haskoning on behalf of Warwickshire County Council.

historical flooding have been identified because places which have flooded in the past may be more susceptible to flooding in the future. Two sources of data relating to historical flooding have been used: local authority information (the relevant SFRA and PFRA) and extents of historical sources of river flooding as provided by the Environment Agency.

2.6 Flood risk approach

River flooding approach

Crossing locations

2.6.1 To determine the river flood risk at locations where the route crosses watercourses and to identify any changes in flood risk as a result of the Proposed Scheme, either existing hydraulic models have been used where available or new hydraulic models have been constructed. Where new models were required flows have been determined in line with current flood estimation guidelines[11].

Flow estimation

2.6.2 The majority of the watercourses that will be crossed by the route within this study area have no known detailed modelling available. Where Flood Zones are associated with these watercourses, the outlines have been determined through the use of broad-scale topographic data, which are considered to be a rough guide when determining areas at risk of flooding and hence have not be used for the design of engineering works. There are other watercourses which have no associated Flood Zones. Flows for these watercourses, at the location of the proposed crossing, have been determined for the 1 in 20 (5%), 1 in 100 (1%), 1 in 100 (1%) with a 20% allowance for climate change and 1 in 1000 (0.1%) annual probability events.

2.6.3 A quick estimation of flow was produced at the crossing locations using the Revitalised Flood Hydrograph model (ReFH) where the contributing catchments were represented within the Flood Estimation Handbook (FEH) CD-ROM[12]. A FEH calculation record for the estimation of flow using ReFH is provided in the hydraulic modelling report (Volume 5, WR-004-010).

Modelling approach

2.6.4 To assess the impact of the proposed River Leam crossing, the existing hydraulic model created for the River Leam Hazard Mapping Study, was made available in a suitable format for this assessment. This model was rerun for the baseline (current) scenario and for the Proposed Scheme scenario. At the other two crossings in this study area, suitable models were not available and therefore new hydraulic models were built utilising the new high resolution Light Detection and Ranging (LiDAR) data collected for the purposes of the Proposed Scheme. Further detail in relation to the hydraulic modelling is included in the hydraulic modelling report (Volume 5, WR-004-001).

2.6.5 There are road embankments and raised infrastructure associated with the three watercourse crossings in this study area which will potentially provide constriction to

[11] Environment Agency (2012) *Flood estimation guidelines*.
[12] Centre for Ecology and Hydrology (2009) *FEH CD-ROM Version 3*, ©NERC (CEH).

flows. The model Digital Terrain Model (DTM) had to be modified to allow for flows through culverts underneath these embankments. In the absence of any survey data of these road embankment culverts, a channel opening of 5m was incorporated at each of these embankments.

2.6.6 The inflow boundaries were mostly applied as steady state flows with unsteady flows applied for certain watercourses. For watercourses with floodplain attenuation such as ponds and lakes or significant obstructions to flow (e.g. due to embankments), the inflows were modelled using unsteady hydrographs. These models were run at longer durations covering the period of the hydrograph and attenuation. The resulting baseline (current) models were run for the 1 in 100 (1%) annual probability with an allowance climate change and 1 in 1000 (0.1%) events over a range of durations depending upon the flow conditions.

2.6.7 The Proposed Scheme models included either viaducts or culverts depending on the scheme design. The railway embankments were represented by modifying the model DTM at those locations. The 1 in 100 (1%) annual probability with an allowance for climate change peak flood levels upstream of the crossings were compared to the baseline (current) levels to assess the change in flood risk. The 1 in 1000 (0.1%) annual probability peak levels were extracted to inform on the vertical alignment of the track.

River flood risk elsewhere along the route

2.6.8 In addition to watercourse crossings, there are sections of the route which are located in areas potentially at risk of river flooding. These have been identified through the use of the Environment Agency Flood Zone mapping. This mapping has been used in preference to SFRA mapping as it is considered more up to date and hence likely to best reflect areas at risk. River flood risk to these sections of the route needs to be determined both to prevent an unacceptable risk to the Proposed Scheme and to prevent it increasing flood risk as result of a reduction in floodplain storage.

Summary of river flooding approach

2.6.9 Due to the number of river crossings, varying complexities, and the amount of data and information available for each, at some locations the modelling approach is highly specific. These locations have been reported as such and further information is included in the hydraulic modelling report (Volume 5, WR-004-010).

Surface water flood risk

2.6.10 The baseline (current) assessment of surface water flood risk was completed using the Flood Maps for Surface Water (FMfSW). The maps utilised for this assessment are listed as:

- 1 in 30 (3.3%) annual probability and surface water flooding greater than 0.1m deep;
- 1 in 30 (3.3%) annual probability and surface water flooding greater than 0.3m deep;
- 1 in 200 (0.5%) annual probability and surface water flooding greater than 0.1m deep; and
- 1 in 200 (0.5%) annual probability and surface water flooding greater than

0.3m deep.

2.6.11 This mapping identified sections of the route which currently are at specific risk from surface water flooding. The risk classification assigned at each location is dependent on which FMfSW the receptor is located within.

2.6.12 The Proposed Scheme has the potential to interrupt surface water flow which would require mitigation to prevent an increase in flood risk. In addition, other design elements such as landscaping will alter the permeability of the ground and hence modify sections of the surface water catchments. The assessment involved determining the land drainage catchments, surface water run-off from these catchments and the capacity of SuDS and culverts.

2.6.13 Land drainage catchments were identified using topographic data (primarily 5m contours, or 1m contours on small or unclear catchments). The assumption was made that linear features such as roads and railways do not act as a cut off for overland flow.

2.6.14 The calculation of Greenfield run-off rates from existing catchments was undertaken using the online SuDS tool[13]. A growth factor of 30% was applied to the 1 in 100 (1%) annual probability rainfall event to determine the flow during this event with an allowance for climate change. A factor of 62% (based on calculations using the Flood Studies Supplementary Report 14[14]) was applied to the 1 in 100 (1%) annual probability rainfall event to determine the flow during the 1 in 1000 (0.1%) annual probability event.

2.6.15 Run-off from modified sections of the catchment as a result of the Proposed Scheme (e.g. landscape areas) which alter the permeability was determined using the Institute of Hydrology 124[15] (IH124) methodology with a value of 0.5 for the soil parameter and a safety factor of 1.2.

2.6.16 Storage volumes were calculated using the SuDS calculator tool assuming that landscape areas will be impermeable. The storage volumes required were taken to be the sum of the attenuation and long-term storage as a conservative approach.

2.6.17 The calculations for the proposed drainage design have been completed in line with the requirements in Volume 1, Section 9.14.

Groundwater flood risk

2.6.18 Groundwater bodies and aquifers present within a 1km buffer of the area of temporary and permanent works have been identified and named on available web-based mapping data for the purposes of the Proposed Scheme.

2.6.19 Field investigations have not yet been undertaken.

Sewer systems flood risk

2.6.20 The risk of flooding from the sewer network has also been addressed as part of this assessment. The sewer network data was provided for this assessment by the relevant

[13] HR Wallingford (2013) UK Sustainable Drainage Guidance and Tool. The Greenfield run-off estimation for sites tool. http://geoservergisweb2.hrwallingford.co.uk/uksd/greenfieldrunoff.aspx.
[14] Institute of Hydrology, (1983).*The Flood Studies Supplementary Report Number 14*.
[15] Institute of Hydrology (2004). *Institute of Hydrology, report number 124*. Flood Estimation for Small Catchments.

water company, Severn Trent Water, to determine locations of the route and other design elements which will be located at areas of risk.

Other sources of flood risk

2.6.21 Reservoir flood risk was assessed using the reservoir inundation maps as shown on the Environment Agency website[16]. The purpose was to identify areas along the route that were at risk of flooding if any reservoirs in the vicinity were to fail.

2.6.22 Canals were identified as another source of potential flood risk, and therefore canals that will be crossed by the Proposed Scheme have been identified in the assessment.

[16] Environment Agency. Reservoir inundation mapping. Available at: http://www.environment-agency.gov.uk/homeandleisure/37837.aspx. Accessed September 2013.

3 Design criteria

3.1 Principal design criteria

3.1.1 The Proposed Scheme will provide a safe and reliable high speed rail link which will be compatible with the existing rail network and also HS1.

3.1.2 The railway will only provide a 'passenger' only service. The railway will not provide 'freight' operation.

3.1.3 The design shall seek to ensure that any impacts as a result of its development will be designed out or minimised as far as practicably possible.

3.2 Flood risk design approach statement

3.2.1 The overall project seeks to ensure that there is no increase in flood risk to any existing receptors as a result of the Proposed Scheme. This will be achieved by ensuring that overall flood storage capacity is maintained including an allowance for climate change.

3.2.2 In line with the NPPF technical guidance, increases in peak rainfall intensity and peak river flow of 20%, as a result of climate change, have been allowed for as per the period 2085 to 2115. This 20% increase has been used for the purposes of assessing flood risk. However, the hydraulic modelling involves sensitivity testing which includes a 20% increase, in addition to the 20% allowance for climate change.

3.2.3 All underbridge and viaduct crossings will be designed so that the 1 in 100 (1%) annual probability flow (with allowance for climate change) can pass underneath. Upstream water levels will not be increased and a minimum of 600mm freeboard will be provided to the bridge soffits above this level which will allow for debris should flooding occur. On main rivers, where possible, a freeboard of 1m has been allowed.

3.2.4 Main River underbridges and viaducts will also accommodate river maintenance requirements and allow for a 5.3m vertical clearance above the floodplain ground level.

3.2.5 Culverts have been designed to convey the 1 in 100 (1%) annual probability flow (with allowance for climate change), with a freeboard of 300mm as a minimum applied for the culvert design. The design has also taken into account submerged inverts and the inclusion of mammal ledges.

3.2.6 River crossings will minimise any requirement for replacement floodplain storage areas.

3.2.7 The proposed rail infrastructure will be protected against inundation in the 1 in 1000 (0.1%) annual probability flood event. This will be achieved through ensuring a freeboard of 1m on the 1 in 1000 (0.1%) annual probability flood level. The railway drainage will be designed to have capacity up to the 1 in 100 (1%) annual probability peak rainfall event. However the design will also ensure that the flood level does not exceed 1m below the track level during the 1 in 1000 (0.1%) annual probability rainfall event.

3.2.8 All drainage will be attenuated in order that peak surface water run-off from the proposed infrastructure is no greater than the existing current day baseline run-off under the 1 in 100 (1%) annual probability peak rainfall event.

3.2.9 All drainage will be designed to ensure that disruption to existing groundwater flood flows will be kept to a minimum, both during and following construction of the permanent works.

3.3 Cross drainage design approach statement

3.3.1 The drainage design will ensure that there is no increase in run-off to the receiving watercourse as a result of the railway.

3.3.2 Surface and ground water drainage shall be provided so as to ensure that water levels do not rise to a level closer than 1m below the rail line.

3.3.3 The route will be designed to ensure safe operation of trains during a 1 in 1000 (0.1%) annual probability event.

3.3.4 As part of the drainage design an allowance of 30% has been added to design events for climate change.

4 Data sources

4.1.1 Consistent with the requirements of the NPPF, this assessment considers the risk of flooding from rivers, overland flow (surface water), rising groundwater, overwhelmed drainage and sewer systems, and artificial sources such as reservoirs, lakes and canals.

4.1.2 The route will lie entirely outside the extent of flooding from the sea and therefore the risk of flooding from tidal sources is not considered in this assessment.

4.1.3 The primary datasets for each source of flooding used to assess the design elements are:

- Ordnance Survey (OS) 1:10,000 mapping;
- topographic survey commissioned for the purposes of the Proposed Scheme (200mm grid resolution LiDAR survey, in digital terrain model and digital surface model format);
- Environment Agency Flood Zone mapping and historic flood mapping;
- the Environment Agency website for reservoir inundation mapping;
- the Warwickshire SFRA[9];
- Warwickshire PFRAs[10];
- Environment Agency national surface water flood mapping datasets specifically the Midlands FMfSW; and
- Severn Trent Water asset mapping.

4.1.4 A high-level review of the risk of flooding and potential impacts is undertaken on the basis of these datasets across all flood sources. Where this review indicates potentially significant impacts on the risk of flooding, or a risk of flooding to the line, further investigation is undertaken specifically hydraulic modelling for areas at risk from river flooding.

5 The Proposed Scheme

5.1 Permanent works

5.1.1 The general design of the Proposed Scheme is described in Volume 2, Section 2.2. The following section describes the main features of the Proposed Scheme in this study area, which are specifically relevant for this FRA.

Route description from south to north

Grand Union Canal and Welsh Road

5.1.2 The route will enter the CFA17 in the south (Map CT-06-088) on Longhole viaduct across the Grand Union Canal, and pass onto embankment to just north-east of Welsh Road Farm. Key features of this section, which have been assessed in this FRA, will include:

- a 140m-long viaduct over the Grand Union Canal (Longhole viaduct); and
- a railway drainage pond to the east.

East of Offchurch: Fosse Way, Offchurch Greenway and Hunningham Road

5.1.3 Continuing to the north-west, the route will run in cutting to the east of Offchurch, passing to the east of Springhill Cottages (Map CT-06-88, E6) and Highfield (Map CT-06-090, H6). Key features of this next section of the route, which have been assessed in this FRA, will include:

- a 2.1km-long cutting at Offchurch, with a maximum depth of 20m under the Fosse Way and Offchurch Greenway. From a point approximately 300m north of the Greenway, raised earthworks will be provided on both sides to provide noise and visual screening of the railway for the northern length of shallower cutting; and
- realignment of Hunningham Road over a length of about 550m approximately 50m to the south of its current location, including the culverting of a tributary of the River Leam at Map CT-06-090, H6.

East of Cubbington: River Leam to South Cubbington Wood

5.1.4 North of Hunningham Road, the route will pass on to a short, low embankment and through a shallow cutting followed by a length of embankment. The route will pass over Ash Beds Brook and the River Leam and its floodplain before returning into cutting towards South Cubbington Wood. Key features of this next section of the route (from Map CT-06-090, H6; to CT-06-091, F5), which have been assessed in this FRA, will include:

- a railway drainage pond adjacent to the new Offchurch auto-transformer station;
- a new culvert carrying the diverted Ash Beds Brook beneath the railway (Map CT-06-090, H6);
- a 50m-long cutting at Ash Beds less than 0.5m deep with raised earthworks on both sides of the rail line to provide visual and noise screening;

- a 110m-long viaduct over the River Leam (Map CT-06-090, A6 and B6);
- replacement floodplain storage to the east of the River Leam viaduct (Map CT-06-090, B5); and
- two further railway drainage ponds: one on the east side of the rail line just south of the River Leam crossing (Map CT-06-090, C6); and one on the west side near Lower Grange (Map CT-06-091, H6).

East of Cubbington: South Cubbington Wood to Coventry Road

5.1.5 Continuing to the north-west the route will enter a short cutting just to the south of South Cubbington Wood before entering a retained cutting where walls will be used to reduce the loss of ancient woodland in South Cubbington Wood. Coming out of retained cutting just north of Rugby Road, the route will continue in cutting to the end of the CFA, just north of Coventry Road. Key features of this next section of the route (from Map CT-06-091, F5; to CT-06-092, C7), which have been assessed in this FRA, will include:

- a 150m-long cutting at Lower Grange increasing in depth to 12m at the start of the retained cutting section (Map CT-06-091, E5);
- a 900m length of cutting from approximately 9m to 12m deep: the east side of the cutting will be retained by a wall over the full length. The west side will change from a wall to open cutting once north of the woodland. The length of single east side wall is likely to require ground anchors buried behind the wall to maintain its stability; and
- a 1.6km-long cutting at Cubbington, which will have a maximum depth of 11m, with raised earthworks on both sides to the length of shallower cutting north of Coventry Road, to provide visual and noise screening.

5.1.6 The route will then continue into the Stoneleigh, Kenilworth and Burton Green area (CFA18) in cutting.

5.2 Temporary works

5.2.1 All contractors will be required to comply with the environmental management regime for the Proposed Scheme, which will include:

- Code of Construction Practice (CoCP); and
- Local Environmental Management Plans (LEMP).

5.2.2 The key requirements of the draft CoCP in relation to flood risk are:

- making appropriate use of the Environment Agency's flood warning service;
- site specific flood risk management plans will be prepared for temporary works at risk of flooding from river, surface water and groundwater sources;
- consider flood risk when planning temporary sites and storing materials;
- obtain consent, as required, for works affecting a watercourse;

- the removal or stopping and sealing of drains and sewers taken out of use;
- no discharge of site run-off to ditches, watercourses, drains or soakaways without agreement of the appropriate authority;
- hoarding and fencing in areas at risk of flooding will be permeable to floodwater, unless otherwise agreed with the Environment Agency or Local Lead Flood Authority; and
- precautions to be taken to prevent damage to services and to avoid pollution during service diversions, excavations and ground penetration.

5.2.3 The temporary works will include both main and satellite construction compounds. These compounds will be utilised for office accommodation, local storage for plant and materials, car parking, material processing facilities and welfare facilities.

5.2.4 Areas adjacent to these compounds may be used for temporary storage of any topsoil stripped as part of the works.

5.2.5 Temporary worker accommodation will also be required for the Proposed Scheme.

6 Existing flood risk

6.1.1 One recorded incident of flooding in the vicinity of the route has been identified in this study area from the available data sources. This event occurred at the location of the proposed River Leam viaduct and was identified through the use of the Environment Agency historical flood maps. The extent of the Environment Agency historic flood map at this location is shown on WR-01-028, D5, (Volume 5: Map Book – Water Resources and Flood Risk).

6.1.2 The Warwick SFRA indicates that there have been no records of historical flooding along the route in this study area. The sources of historical flooding mapped in the SFRA are river, surface water, canal breaching, artificial drainage and unknown. Although there are no recorded incidents of flooding along the route, the SFRA indicates that there have been flood events in Cubbington and Offchurch which are within 1km of the route centreline. These identified incidents were river flooding and downstream of the Proposed Scheme.

6.1.3 The Warwickshire PRFA has also been used to identify potential locations of flooding in the vicinity of the route, however this mapping does not show any incidents of historical flooding at the location of the route. The PFRA mapping indicates that an incident of historical flooding occurred to the north of Offchurch. Owing to the location of the event, it is likely to be the same incident as recorded on the Environment Agency historical flood maps (i.e. at the location of the proposed River Leam viaduct as shown on WR-01-028, D5, Volume 5: Map Book – Water Resources and Flood Risk).

6.2 River flooding

6.2.1 River flood risk is the risk of flooding posed by rivers and streams. The risk in CFA17 is from the River Leam and its tributaries. The areas at risk of flooding from this source are shown in Volume 5 WR-05 and WR-06.

6.2.2 The assessment of baseline (current) flood risk involved identifying watercourse crossings and the associated risk through the use of the Flood Zones. The results of this assessment are provided in Table 2. The watercourse identifier references have been taken from map WR-01-028 (Volume 5: Map Book – Water Resources and Flood Risk).

Table 2: Offchurch and Cubbington sources of river flooding

Watercourse identifier and map reference	Crossing name	Watercourse	1 in 100 (1%) + climate change flow (m^3/s)	Risk level	Receptor vulnerability
SWC-CFA17-001 WR-01-028, H6 (Volume 5: Map Book – Water Resources and Flood Risk)	Longhole viaduct	Ordinary watercourse (tributary of the River Leam)	4.7	Very high	Less vulnerable
SWC-CFA17-004 WR-01-028, E5, (Volume 5: Map Book – Water Resources and Flood Risk)	Ash Beds culvert	Ordinary watercourse (tributary of the River Leam)	2.46	Very high	Less vulnerable

Watercourse identifier and map reference	Crossing name	Watercourse	1 in 100 (1%) + climate change flow (m^3/s)	Risk level	Receptor vulnerability
SWC-CFA17-005 WR-01-028, D5, (Volume 5: Map Book – Water Resources and Flood Risk)	River Leam viaduct	Main river (River Leam)	145.97	Very high	Less vulnerable

6.2.3 The Environment Agency Flood Zone mapping indicates two main areas of the Proposed Scheme to be at risk from river flooding in this study area. These are at and in the vicinity of the River Leam Viaduct and the Longhole Viaduct as shown on map WR-01-028 (Volume 5: Map Book – Water Resources and Flood Risk). The Environment Agency flood mapping covers watercourses with catchments greater than 0.5km2 and hence there are no identified Flood Zones for the culvert crossing of the River Leam tributary (map WR-01-028, E5, Volume 5: Map Book – Water Resources and Flood Risk). In addition the Environment Agency Flood Zone mapping in the vicinity of the Longhole Viaduct is misaligned from the watercourse at map WR-01-028, H6 (Volume 5: Map Book – Water Resources and Flood Risk).

6.2.4 Hydraulic modelling as detailed in Section 2.6 of the report was carried out to provide a more accurate representation of river flood risk along the route, specifically at locations where the route would cross a watercourse. The modelling provided flood extents for the 1 in 100 (1%) annual probability event with a 20% allowance for climate change and for the 1 in 1000 (0.1%) annual probability event. The flood extents and levels as determined through hydraulic modelling are further detailed in the hydraulic modelling report (Volume 5, WR-004-010).

6.2.5 The hydraulic modelling redefines the Flood Zones along the tributary of the River Leam (as shown on map WR-06-044b, E6, Volume 5: Map Book – Water Resources and Flood Risk) and identifies that the Longhole viaduct is within Flood Zone 3b and hence classed as at a very high risk, in line with Table 1.

6.2.6 Similarly the Environment Agency flood mapping indicates that the proposed Ash Beds culvert carrying the River Leam tributary (WR-01-028, E5, (Volume 5: Map Book – Water Resources and Flood Risk) is located within Flood Zone 1. However, the Proposed Scheme will cross this watercourse and hence will be located within the area at risk during the 1 in 20 (5%) annual probability event. Therefore the risk classification given to this location is very high.

6.2.7 The River Leam viaduct would be located within the Environment Agency Flood Zone 3. These maps are not split into Flood Zones 3a and 3b as required for risk classification (Table 1), however given the Proposed Scheme crosses this Main River it will cross Flood Zone 3b (very high risk).

6.2.8 The vulnerability classification provided in the table above is based on the NPPF and relates to the vulnerability of existing development at risk of river flooding. In line with the NPPF, a less vulnerable classification has been given, as shown in Table 4, because the land at risk is utilised for agricultural purposes (land and buildings used for agriculture and forestry). This is based on Hunningham Road, the adjacent road to the Ash Beds culvert, (map WR-01-028, E5, Volume 5: Map Book – Water Resources and

Flood Risk), being categorised as less vulnerable, i.e. it is not essential infrastructure acting as a mass evacuation route.

6.2.9 The other locations along the route, not identified in Table 2, are considered to be at either a low risk or no risk of river flooding.

6.3 Surface water/overland flow

6.3.1 This section is an examination of the existing flood risk posed by rainfall falling on the ground surface, referred to as surface water flooding. It is examined in terms of the water flowing over the ground surface that has not entered a natural drainage channel or artificial drainage system.

6.3.2 The areas at risk from surface water flooding are shown on map WR-01-028 and WR-01-029 (Volume 5: Map Book – Water Resources and Flood Risk). Table 3 details the risk to the development from this source of flooding.

Table 3: Offchurch and Cubbington sources of surface water flooding

Description of surface water flooding location	Description of possible influence to the Proposed Scheme	Risk
Areas surrounding the Grand Union Canal at the proposed Longhole Viaduct WR-01-028, H6, (Volume 5: Map Book – Water Resources and Flood Risk)	The route will cross a large area susceptible to surface water flooding which is associated with the canal and a tributary of the River Leam. This area at risk is primarily at a low and medium risk, although areas adjacent to the western site of the track are located at a high risk.	High
The area between Welsh Road to Burnt Firs Reservoir along the route WR-01-028, F6, (Volume 5: Map Book – Water Resources and Flood Risk)	The route will cross three relatively small areas susceptible to surface water flooding. There are also small isolated areas to both the east and west of the road which are at risk. These small areas are categorised as being at low, medium and high risk of flooding from this source.	High
At the proposed Ash Beds culvert WR-01-028, E5, (Volume 5: Map Book – Water Resources and Flood Risk)	The route will cross an area susceptible to surface water flooding at the location of the Ash Beds culvert. This area is categorised as being at a high risk of flooding from this source.	High
North of Offchurch, between Field's Farm and the River Leam WR-01-028, D5, (Volume 5: Map Book – Water Resources and Flood Risk)	The route will cross isolated areas susceptible to surface water flooding which are categorised as being at a low and medium risk. At the northern end of this location, the route will cross the River Leam, which has an associated area categorised as being at a high risk of surface water flooding.	High
South east of Cubbington WR-01-029, G6, (Volume 5: Map Book – Water Resources and Flood Risk)	The route will cross and be located in close proximity to areas susceptible to surface water flooding which is categorised as being at a low and medium risk.	Medium
North east of Cubbington WR-01-029, F6, (Volume 5: Map Book – Water Resources and Flood Risk)	Various areas to the north and west of the proposed route are susceptible surface water flooding. These areas are categorised as being at a low and medium risk.	Medium

6.3.3 There are six locations along the route in this study which have been identified to be at risk from surface water flooding from the Environment Agency FMfSW. At the majority of these locations the risk of surface water flooding ranges from low to high; however, as a conservative approach, the highest level of risk has been assigned.

Therefore at four locations the risk is considered high and at two locations the risk is considered medium.

6.3.4 In line with the risk category matrix provided in Table 1, and the data available for this FRA, all other locations along the route within this study area are classed to be at no risk from surface water flooding.

6.4 Groundwater

6.4.1 Groundwater flood risk has been qualitatively assessed based on hazard identification and evaluation using the conceptual understanding of the ground conditions at the location of the Proposed Scheme. The assessment of the current groundwater flood risk is based on the presence or otherwise of an aquifer and the relative depth of groundwater level, as well as historical information on the occurrence of groundwater flooding incidents.

6.4.2 The study area overlies Triassic mudstones which are designated a Secondary B aquifer. In some areas, these are overlain by glacial clays, sands and gravel, with alluvium found within the river valleys. The alluvium deposits are also designated as Secondary A aquifers.

6.4.3 Limited groundwater data has been made available within the study area. However it is considered that groundwater flow is likely to be towards watercourses and groundwater, especially within the alluvium, and that groundwater may be within 2m of ground level.

6.4.4 Local Authority information, presented in the relevant SFRA and PFRA, does not record any instances of groundwater flooding.

6.4.5 The overall groundwater flood risk category assigned in this study area is low.

6.5 Sewer systems

6.5.1 Sewer infrastructure is a potential source of flood risk in the event of a failure. Due to the nature of the closed sewer system, sewer flooding will only be caused if there is a blockage or a leak or if there is a rainfall event greater than the design capacity of the network.

6.5.2 The risk to the route from the sewer network has been determined based on the location of development in relation to the network and the proximity and potential flow paths from inspection covers. Flow paths have been assessed through the use of LiDAR and OS mapping. A summary of this assessment is included in Table 4. The approximate location where the route will cross the existing water supply and sewer network has also been taken from maps CT-06-088b to 092a.

Table 4: Offchurch and Cubbington sources of sewer network flooding

Source	Location	Supplier	Comment	Risk
Sewer	CT-06-089, D5	Severn Trent Water	The route will be located within 200m of a sewer inspection cover. However the topography of the area indicates that there are no flow paths between the surcharge point and the route.	Low
Sewer	CT-06-090, F7	Severn Trent Water	The route will cross the sewer network, however, based on the topography of the area, there are no known flow paths between surcharge points and the route.	Low

6.5.3 There is one location in this study area where the route will cross the sewer network. However there are no inspection covers located in close proximity to the Proposed Scheme and the topography of the area indicates that there are no flow paths from surcharge points to the route. Similarly, at another location an inspection cover is located within 200m of the route although the topography indicates that there will be no flow paths for flood water to inundate the Proposed Scheme.

6.6 Artificial sources

6.6.1 Artificial sources of flood risk describe a mechanism whereby flooding would be the result of failure of infrastructure that impounds water such as in a canal or reservoir.

6.6.2 There is one canal within this study area that poses a risk to the Proposed Scheme. The Grand Union Canal will be crossed by the proposed Longhole viaduct as shown on map WR-01-028 (Volume 5: Map Book – Water Resources and Flood Risk).

6.6.3 Topographic data (specifically LiDAR) indicates that the Grand Union Canal is not raised above surrounding ground level and hence there is no risk of structural breaching when the water level is maintained at the design level. However there is a small embankment which could be overtopped if water levels rise above the design level. Water levels in canals are highly maintained and thus overtopping or failure is considered unlikely. Therefore in line with the risk category matrix in Table 1 it is considered that the flood risk from this source is low.

6.6.4 There is one location along the Proposed Scheme in this study that would be at risk of flooding as a result of reservoir failure. Upstream of Offchurch and located south of Thurlaston is Draycote Water, a designated reservoir. Should this reservoir fail, flood water would flow along the River Leam, in a westerly direction, to the Proposed Scheme at the River Leam viaduct (map WR-01-028, D5, Volume 5: Map Book – Water Resources and Flood Risk). Even though this area is considered to be at risk, in the unlikely event of reservoir failure, Draycote Water is situated in excess of 10km upstream of the Proposed Scheme and hence the flood water would be at low velocity when it reaches the Proposed Scheme. Low velocity flood water is likely to cause less damage and pose a lower risk to life. In addition the Environment Agency reservoir inundation maps broadly follow the areas at risk from river flooding.

6.6.5 In addition, due to the strict regulations and high maintenance associated with reservoirs the risk of breaching is considered unlikely. In line with the risk category matrix in Table 1 the risk of flooding from this source is considered low.

6.7 Summary

6.7.1 The Proposed Scheme will be located within the Environment Agency Flood Zone 3 and because it crosses watercourses it will also be in Flood Zone 3b. Therefore it is concluded that the Proposed Scheme will be within areas that are classified as being potentially at very high risk from river flooding in this study area. The only land uses at risk in this study area (which could be impacted as result of the Proposed Scheme) are classed as less vulnerable.

6.7.2 There are six locations along the route which have been identified to be at risk from surface water flooding. The risk at these locations generally ranges from low to high,

although as a conservative approach the highest level of risk has been assigned. Therefore four locations have been categorised as at a high risk and two locations at a medium risk.

6.7.3 There is a risk of groundwater flooding where works are located close to the rivers and in the areas of alluvium. Works below the existing ground level, particularly in the river valleys will also be at risk. The overall groundwater flood risk in this study area is low.

6.7.4 Even though the Proposed Scheme will cross, or be located in close proximity to the sewer systems at two locations, there are no known flow paths of flooding to the Proposed Scheme. As a result the flood risk from this source is considered low within this study area.

6.7.5 Water levels within canals are continually maintained and hence the chance of overtopping and breaching, and thus flood risk from this source is considered low. Similarly due to the strict monitoring and maintenance requirements, the risk of reservoir flooding to the development is considered low.

7 Flood risk management measures

7.1 River flood risk

Flood risk to proposed scheme

7.1.1 The Proposed Scheme will be raised above floodplain crossings such that the risk of river flooding is less than during the 1 in 1000 (0.1%) annual probability. Therefore the mitigation measures included in the design have ensured that there are no instances where the Proposed Scheme would be at significant risk of river flooding, and consequently no specific mitigation is required.

Impact of proposed scheme

7.1.2 At all floodplain crossings, replacement floodplain storage would be provided upstream of the Proposed Scheme for losses in floodplain storage, including viaduct piers, embankments and all associated development.

Longhole viaduct

7.1.3 Hydraulic modelling at this location suggests that the Proposed Scheme will result in an afflux of up to 39mm, extending to a maximum distance of 90m upstream of the Longhole viaduct during the 1 in 100 (1%) annual probability event with an allowance for climate change. This change in flood level causes a minor impact. This minor impact would be reduced through the incorporation of replacement floodplain storage, which is proposed upstream of the viaduct.

Ash Beds culvert

7.1.4 Hydraulic modelling at this location suggests that the Proposed Scheme will result in an afflux of up to 31mm, extending to a maximum distance of 12m upstream of the culvert during the 1 in 100 (1%) annual probability event with an allowance for climate change. This change in flood level causes a minor impact that is localised to the proposed crossing and thus the wider impact is considered negligible. This impact could be reduced through the incorporation of replacement floodplain storage, however given the negligible impact assigned at this location mitigation is not deemed necessary.

River Leam viaduct

7.1.5 Hydraulic modelling at this location suggests that the Proposed Scheme will result in an afflux of up to 13mm, extending to a maximum distance of 181m upstream of the River Leam viaduct during the 1 in 100 (1%) annual probability event with an allowance for climate change. This change in flood level causes a minor impact. This minor impact would be reduced through the incorporation of replacement floodplain storage, which is proposed 120m upstream of the viaduct.

Mitigation for temporary works

7.1.6 The temporary works have the potential to result in an increased river flood risk and be at risk of flooding from this source. The proposed mitigation and measures to prevent an unacceptable risk of river flooding for the temporary works includes signing up to the Environment Agency flood warning system for the "River Leam – Low-lying land and roads between Grandborough and Leamington, including Long

Itchington". Any temporary crossings will be designed to prevent an increased flood risk through ensuring sufficient capacity during the 1 in 100 (1%) annual probability event; an indication of the flows which will be considered are included in Table 4.

7.2 Surface water flood risk

Flood risk to Proposed Scheme

7.2.1 In this study area, the areas categorised as being at a high risk of surface water flooding are generally associated with the three watercourses identified in the river flooding sections in this report. At these locations the scheme design will ensure that the track is situated above the 1 in 1000 (0.1%) annual probability event flood level with a 1m freeboard. Therefore as long as there is no blockage of these structures, a low surface water flood risk to the track is anticipated at these locations.

7.2.2 At the other three locations where the route potentially crosses surface water flow paths, the track will either be raised on an embankment and/or the track drainage system will direct surface water flow away from the Proposed Scheme. Therefore, as long as the collection systems and surface water culverts are designed with sufficient capacity, there should be no backing up, and no expected risk of flooding to the Proposed Scheme.

Impact of Proposed Scheme

7.2.3 Potential increases in peak discharge rates of surface water run-off will be attenuated prior to discharging to the receiving watercourse. Any additional surface water to be discharged will be at a trickle rate to prevent exceeding the current capacity of the receiving watercourse.

7.3 Risk of flooding from groundwater

Flood risk to Proposed Scheme

7.3.1 There is no anticipated effect on the risks of flooding from groundwater within the study area to the proposed scheme. Local Authority information in groundwater flooding, as reported on the relevant SFRA and PFRA, has been consulted to identify areas where existing sources of groundwater flooding are present in the area. No such areas have been identified.

Impact of the Proposed Scheme

7.3.2 Development may increase the risk of groundwater flooding where a structure us built across existing groundwater flow paths there altering the flow regime. The Proposed Scheme within this study area does not include any deep impermeable structures and therefore it is concluded that the Proposed Scheme is unlikely to significantly increase the risk of groundwater flooding.

7.4 Risk of flooding from drainage systems

7.4.1 There will be a low risk of flooding from drainage systems to the Proposed Scheme, and there will be no anticipated effects on the risks of flooding from drainage systems within the study area arising from the Proposed Scheme. Therefore, no specific mitigation would be required.

7.5 Risk of flooding from artificial sources

Flood risk to Proposed Scheme

7.5.1 There are no instances where the Proposed Scheme would be at significant risk of flooding from artificial sources, and consequently no specific mitigation is required.

Impact of the Proposed Scheme

7.5.2 Although the Proposed Scheme is at risk of flooding resulting from the complete failure of Draycote Water, the replacement floodplain storage provided to mitigate the potential effects of the River Leam viaduct would serve to either fully or partially offset any potential effects of the Proposed Scheme on flooding from this source. Due to the low probability of such flooding occurring, and the likely low significance of any impacts arising from the Proposed Scheme, it is not considered practical to provide additional mitigation for this scenario.

8 Post-development flood risk assessment

8.1 River flooding

8.1.1 The key design elements of the proposed route with potential flood risk considerations have been modelled for this FRA. The modelling methodology and results specific for each watercourse crossing are included in the modelling report (Volume 5, WR-004-010). A summary of the results are presented in Table 5. The watercourse identifier references have been taken from map WR-01-028 (Volume 5: Map Book – Water Resources and Flood Risk).

Table 5: Offchurch and Cubbington river flood risk

Watercourse identifier and map reference	Crossing name	1 in 100 (1%) + climate change flow (m^3/s)	Change in flood level 1 in 100 (1%) +climate change (mm)	Change in flood level 1 in 1000 (0.1%) (mm)	Proposed Scheme 1 in 1000 (0.1%) level (m AOD)	Length of impacted upstream reach[17] (m)
SWC-CFA17-001 WR-05-044b, E6, (Volume 5: Map Book – Water Resources and Flood Risk)	Longhole viaduct	4.70m^3/s	39mm	85mm	64.55m AOD	90m
SWC-CFA17-004 WR-05-045, D6 (Volume 5: Map Book – Water Resources and Flood Risk)	Ash Beds culvert	2.46m^3/s	31mm	109mm	60.89m AOD	12m
SWC-CFA17-005 WR-05-046, I6 (Volume 5: Map Book – Water Resources and Flood Risk)	River Leam viaduct	145.97m^3/s	13mm	27mm	56.73m AOD	181m

8.1.2 The hydraulic modelling at the proposed Ash Beds culvert, the River Leam viaduct and the Longhole viaduct indicates that at these locations the Proposed Scheme will have a minor impact on flood levels during the 1 in 100 (1%) annual probability with an allowance for climate change event.

8.1.3 The Proposed Scheme involves the realignment of the River Leam tributary at the location of the Longhole viaduct as shown on Map CT-06-088, H6. The realignment will divert the watercourse around the southern viaduct abutment. The hydraulic modelling at this location incorporates the watercourse realignment. Therefore the Proposed Scheme, both the viaduct and watercourse realignment combined, will have a minor impact on flood levels.

8.1.4 The upstream reaches impacted as a result of the proposed structures, as shown in Table 5, are surrounded by less vulnerable land use. In addition, the downstream areas of the structures are also surrounded by less vulnerable development. Therefore no vulnerable development would be at risk as a result of these minor changes in flood levels. An area of land has been identified that is suitable to provide replacement

[17] Length of reach upstream of the Proposed Scheme along which flood levels during the 1 in 100 (1%) annual probability+ CC are greater than 10mm.

floodplain storage, therefore reducing the impact. The replacement storage possible within this area is greater than the volume lost due to the Proposed Scheme.

8.1.5 Even though the Proposed Scheme is located in areas at a very high risk of flooding from the river, the design will ensure that the track is above the 1 in 1000 (0.1%) annual probability flood level with an appropriate freeboard. Therefore it can be concluded that the Proposed Scheme will ensure that the track is at an acceptable level of flood risk from this source, and that the works will not cause an increased risk to any vulnerable receptors.

8.1.6 Watercourses pose a river flood risk to the other design elements in this study area. The areas at risk from river flooding are shown on maps WR-05-044b to WR-05-046b and WR-06-044b to WR-06-046b (Volume 5: Map Book – Water Resources and Flood Risk), and are based on the hydraulic modelling results rather than Environment Agency Flood Zone mapping. The river flood risks to these works are included in Table 6.

Table 6: Other design elements at risk from river flooding

Works at risk	Watercourse identifier and map reference	Location description	Description of the works and flood risk	Risk
Landscaping	SWC-CFA17-001 WR-05-044b, E6, (Volume 5: Map Book – Water Resources and Flood Risk)	Longhole viaduct	Proposed landscaping works encroach into the areas at risk from river flooding.	High
Landscaping Earthworks Highways Other	SWC-CFA17-004 WR-05-045, D6 (Volume 5: Map Book – Water Resources and Flood Risk)	At and in the vicinity of the proposed Ash Beds culvert	The proposed realignment of Hunningham Road requires a new culvert for this watercourse. The works at this location also involve landscaping, earthworks, an access track and two maintenance access points.	Very high
Landscaping Earthworks	SWC-CFA17-005 WR-05-046, I6 (Volume 5: Map Book – Water Resources and Flood Risk)	River Leam viaduct	Proposed landscaping and earthworks encroach into the areas at risk from river flooding. Mains utility works will also be located in this area at risk.	High

8.1.7 At one location (WR-05-046, I6, (Volume 5: Map Book – Water Resources and Flood Risk) the earthworks will be located in an area at risk from river flooding. These earthworks are required for the proposed viaduct and hence have been included in the hydraulic modelling, which has shown the works to have a minor impact on river flood risk.

8.1.8 The proposed realignment of Hunningham Road will require the installation of a new watercourse culvert, see map WR-05-045 D6 (Volume 5: Map Book – Water Resources and Flood Risk). However, this will be adjacent the location of an existing culvert, which will be removed as part of the works. The land use both upstream and downstream of this culvert is classed as less vulnerable. The new culvert should be at least the same size as the existing culvert to ensure that there is no impact on flood risk, although any change is flood risk will be limited to less vulnerable receptors.

8.1.9 Temporary works as required for the construction phase are also located in areas at risk from river flooding. The areas at risk from river flooding are shown on maps WR-

05-044b to WR-05-046b and WR-06-044b to WR-06-046b (Volume 5: Map Book – Water Resources and Flood Risk) and are based on the hydraulic modelling results rather than Environment Agency Flood Zone mapping. The locations of various temporary works are shown in maps CT-05-088b to 092a. The temporary works at risk are listed in Table 7.

Table 7: River flood risk to temporary works

Watercourse identifier and map reference	Receptor	Comment	Risk
SWC-CFA17-001 WR-05-044b, E6, (Volume 5: Map Book – Water Resources and Flood Risk)	Ordinary watercourse (tributary of the River Leam)	The only temporary works in this area at risk are the pedestrian and light vehicle access between the banks via an existing bridge and the proposed location of temporary construction fencing. These works are identified in the area at risk during the 1 in 20 (5%) annual probability event.	Very high
SWC-CFA17-004 WR-05-045, D6 (Volume 5: Map Book – Water Resources and Flood Risk)	Ordinary watercourse (tributary of the River Leam)	Flood mapping is not available at this crossing; however the temporary works which cross and are located in close proximity to the watercourse have been identified. A plant crossing will be required over the watercourse and temporary fencing will cross the watercourse.	Very high
SWC-CFA17-005 WR-05-046, I6 (Volume 5: Map Book – Water Resources and Flood Risk)	Main river (River Leam)	A temporary plant crossing and temporary fencing over the River Leam will be required. A new track/haul road will be required to allow construction compound and site access which will be located in the area at risk during the 1 in 20 (5%) annual probability event.	Very high

8.1.10 The temporary works at the location of the Longhole Viaduct (WR-05-044b, E6, Volume 5: Map Book – Water Resources and Flood Risk) and the River Leam Viaduct (WR-05-046, I6, Volume 5: Map Book – Water Resources and Flood Risk) are either fully or partially located within the areas at risk of river flooding during the 1 in 20 (5%) annual probability event. There are no river flood extents available for the Ash Beds Culvert crossing (WR-05-045, D6, Volume 5: Map Book – Water Resources and Flood Risk), however temporary works both cross this watercourse and are located on the banks of this watercourse and hence a very high risk of river flooding has been assigned.

8.1.11 Hydraulic modelling is not considered necessary for the temporary works because the works will be constructed in line with the CoCP and thus the design will consider river flood risk. Therefore temporary works will not result in an increased flood risk to any existing receptors.

8.1.12 The hoarding and fencing around a site for security purposes has the potential to alter flow paths and thus impact on flood risk at the two locations identified in Table 7. However hoarding and fencing in areas at risk of flooding will be permeable to floodwater (as outline in the design criteria in Section 0 of this report), unless otherwise discussed with the Environment Agency or Local Lead Flood Authority. This will ensure that the floodplain continues to function effectively for storage and conveyance of floodwater.

8.1.13 The temporary works other than those outlined in Table 7 are considered to be at low risk of river flooding.

8.2 Surface water/overland flow

8.2.1 The proposed track will result in increased run-off rates due to a reduction in infiltration capacity. Therefore the entire length of the track may be at risk from this source and could increase risk elsewhere.

8.2.2 In addition, the track drainage has the potential to increase flood risk in receiving watercourses if not attenuated. In this study area there are five proposed balancing ponds, these are located as follows:

- to the north of the Grand Union Canal (CT-06-088, F5, Volume 1, CFA17, map book);
- to the south of the Welsh Road realignment (CT-06-089, G8, Volume 1, CFA17, map book);
- adjacent to the tributary of the River Leam (CT-06-090, G8, Volume 1, CFA17, map book); and
- both on the north and south banks of the River Leam at the location of the crossing (CT-06-089, C8, and CT-06-091, H6, Volume 1, CFA17, Map Book).

8.2.3 The outfall from these balancing ponds will be attenuated and agreed with the Environment Agency to prevent an increase in risk.

8.2.4 The route has the potential to interrupt surface water movement, which could result in an increase in surface water flood risk. The Environment Agency FMfSW indicates overland flow paths. To the north east of the proposed Longhole viaduct the FMfSW indicates an overland flow path for surface water that would flow from the north east, across Welsh Road, and will be crossed by the Proposed Scheme and potentially discharge to or pond to the north of the canal. This area shown to be at risk from surface water flooding is not associated with a watercourse and is shown on WR-01-028, H6, (Volume 5: Map Book – Water Resources and Flood Risk). Assuming surface water will flow in this direction it is anticipated to be collected in the balancing pond, to the north of the Grand Union Canal and hence the Proposed Scheme (particularly the track) will be at a low risk from this source of flooding. In addition, the interruption of surface water flow, as a result of the Propose Scheme, at this location would not significantly impact on surface water flood risk elsewhere.

8.2.5 The FMfSW highlights a linear area at risk from surface water flooding, which is associated with the dismantled railway to the north of Sutton Spinney and is shown on WR-01-028, F6, (Volume 5: Map Book – Water Resources and Flood Risk). However, this area at risk is likely to be due to low elevations associated with the dismantled railway rather than a surface water flow route and hence it is not considered that the Proposed Scheme would interrupt surface water flows at this location.

8.2.6 To the north of the proposed Ash Beds culvert are areas at risk from surface water flooding, potentially connected via a field drain. These areas at risk do not appear to follow a specific flow path, although based on the topography of the area they would drain to the River Leam, either directly or via the tributary of the River Leam (SWC-CFA17-004). Any flow to the north of the Proposed Scheme, flowing south, will

discharge to the proposed swale/infiltration trench to be provided at the embankment toe. Any surface water to the south of the Proposed Scheme at this location will flow south and away from the track, towards the tributary of the River Leam (SWC-CFA17-004) or the River Leam. Therefore at this location, whether the Proposed Scheme will intercept surface water movement or not, surface water will be discharged to the River Leam (as it does at present) without causing an increased risk elsewhere.

8.2.7 The FMfSW indicates a flow path of surface water that is not associated with a watercourse, but discharges to the River Leam immediately downstream of the proposed River Leam viaduct WR-01-028, C5, (Volume 5: Map Book – Water Resources and Flood Risk). The flow path is from the north west to the south east and will be crossed by the Proposed Scheme in the northern reach. The majority of this flow path is located adjacent to the toe of the track embankment and hence not interrupted as a result of the Proposed Scheme. In the upstream reach of the flow path, water interrupted as a result of the Proposed Scheme will be collected in the track drainage and eventually discharged to the River Leam at a similar location as at present.

8.2.8 Two other flow paths for surface water have been identified in the northern area of this study area, to the west of North Cubbington Wood WR-01-029, F6 and E5, (Volume 5: Map Book – Water Resources and Flood Risk). However, these currently flow away from the track and hence the Proposed Scheme will not result in an interruption of flow paths at these locations.

8.2.9 The potential impact of the Proposed Scheme on surface water movement, not identified as above, will be incorporated within the scheme design. Therefore the works will have no impact on surface water flood risk.

8.2.10 There are various aspects of the other design elements which will be at risk from surface water flooding. The surface flood risks to the other design elements, as identified from the Environment Agency FMfSW are included in Table 8.

Table 8: Surface water flood risks to other design elements of the Proposed Scheme

Works at risk	Location description	Description of possible influence to the Proposed Scheme	Risk
Landscaping Earthworks Highways Other	To the north of the Grand Union Canal at the proposed Longhole Viaduct WR-01-028, H6, (Volume 5: Map Book – Water Resources and Flood Risk)	At this location there is a relatively large area at risk from surface water flooding which is categorised primarily at a medium risk, although various areas are at either a low or high risk. The other design elements in this area are landscaping, realignment of a current access track (E2994), earthworks and embankment, a proposed balancing pond and a proposed access track.	High
Highways	Welsh Road in close proximity to the proposed underpass 130-S1 WR-01-028, G6, (Volume 5: Map Book – Water Resources and Flood Risk)	The proposed realignment of Welsh Road will be located in an area at a low and medium risk from surface water flooding.	Medium

Works at risk	Location description	Description of possible influence to the Proposed Scheme	Risk
Landscaping Earthworks	Burnt Firs Reservoir (undesignated) WR-01-028, F6, (Volume 5: Map Book – Water Resources and Flood Risk)	A high risk from surface water flooding is associated with the undesignated Burnt Firs Reservoir. However as part of the Proposed Scheme this water body will be drained and filled. Earthworks and an embankment are proposed at this location and run-off in this area will be drained via the proposed track drainage. Given that this reservoir is to be in filled, it is anticipated that the risk from this source will be reduced. Hence a low risk has been categorised.	Low
Highways Landscaping Others	Welsh Road/Fosse Way junction WR-01-028, F6, (Volume 5: Map Book – Water Resources and Flood Risk)	The other design elements proposed at this location are the realignment of Welsh Road, landscaping, culverting for drainage requirements, a balancing pond with associated access, realignment of Fosse Way and mains utility works. The areas at risk are categorised as being at a low and medium risk of surface water flooding.	Medium
Landscaping Earthworks Other	Dismantled railway, adjacent Sutton Spinney WR-01-028, F6, (Volume 5: Map Book – Water Resources and Flood Risk)	The other design elements at risk are landscaping, earthworks, a footpath diversion, an overbridge and mains utility works. The areas at risk are categorised as being at a low and medium risk of surface water flooding.	Medium
Highways Landscaping Earthworks Other	Hunningham Road and the Ash Beds culvert WR-01-028, E5, (Volume 5: Map Book – Water Resources and Flood Risk)	The other design elements at this location include the realignment of Hunningham Road and the associated earthworks and mains utility works. The works at this location also involve landscaping, an access track and two maintenance access points. The areas at risk are categorised as high, medium and low.	High
Landscaping Earthworks	North of Field's Farm WR-01-028, D5, (Volume 5: Map Book – Water Resources and Flood Risk)	The other design elements located in areas at risk are earthworks and landscaping, which are located in areas of primarily low and medium risk, with small areas at a high risk.	High
Landscaping	River Leam crossing WR-01-028, D5, (Volume 5: Map Book – Water Resources and Flood Risk)	The area at risk from surface water flooding at this location is limited to the extent of the watercourse, and the surface water flow path discharging to the River Leam downstream of the proposed viaduct. The other design elements in this area at risk are landscaping and limited areas of embankment in the north. These works are within an area at low and medium risk of surface water flooding.	Medium
Highways	Rugby Road crossing WR-01-029, F6, (Volume 5: Map Book – Water Resources and Flood Risk)	The proposed realignment of Rugby Road and the associated landscaping is located in an area at low and medium risk of surface water flooding.	Medium

8.2.11 There are nine locations where other design elements are located in areas susceptible to surface water flooding. In general, these areas range from low to high risk and as a conservative approach the highest level of risk has been assigned. Therefore, three of the nine locations are categorised as being at a high risk, five at a medium risk and one at a low risk of surface water flooding.

8.2.12 The other design elements not listed in Table 8 are considered to be at no risk from surface water flooding in line with the flood risk category matrix.

8.2.13 All other design elements, including those additional to Table 8, have the potential to increase surface water run-off rates through reduced infiltration capacity. The design for the Proposed Scheme includes surface water run-off management (such as drainage channels and balancing ponds) to prevent an increased risk of flooding from this source both on site and in neighbouring areas.

8.2.14 Table 9 details the risk to the temporary design elements from surface water flooding.

Table 9: Sources of surface water flooding to temporary works

Description of surface water flooding location	Description of possible influence on temporary design elements	Risk
To the north of the Grand Union Canal. WR-01-028, H6, (Volume 5: Map Book – Water Resources and Flood Risk)	Longhole viaduct satellite compound (north), temporary fencing and plant and material storage are located in areas at low and medium risk of surface water flooding.	Medium
Burnt Firs Reservoir (undesignated) WR-01-028, F6, (Volume 5: Map Book – Water Resources and Flood Risk)	A temporary topsoil and storage area is located in this area at risk from surface water flooding. Given that this reservoir is to be infilled, it is anticipated that the risk from this source will be reduced.	Low
Dismantled railway, adjacent Sutton Spinney WR-01-028, F6, (Volume 5: Map Book – Water Resources and Flood Risk)	Temporary fencing will cross this area which is at a low and medium risk of surface water flooding.	Medium
Hunningham Road and the Ash Beds culvert WR-01-028, E5, (Volume 5: Map Book – Water Resources and Flood Risk)	A temporary access track and fencing will be required in this area which is at a low, medium and high risk of surface water flooding.	High
North of Farms Farm WR-01-028, D5, (Volume 5: Map Book – Water Resources and Flood Risk)	A temporary topsoil and storage area is located in this area at risk from surface water flooding. These areas are located at low and medium risk of surface water flooding.	Medium
River Leam viaduct WR-01-028, D5, (Volume 5: Map Book – Water Resources and Flood Risk)	A temporary plant crossing, fencing and noise fencing will cross an area at high risk from surface water flooding.	High
Rugby Road crossing WR-01-029, F6, (Volume 5: Map Book – Water Resources and Flood Risk)	Cubbington retaining wall satellite compound, temporary site access and haul roads and temporary fencing will be located in areas at low and medium risk of surface water flooding.	Medium

8.2.15 There are seven temporary design elements in this study area which have been identified to be at risk from surface water flooding from the Environment Agency FMfSW. A conservative approach has been taken in categorising risk as outlined earlier in this section. Therefore, in line with the flood risk category matrix (Table 1) a high risk of surface water flooding has been categorised at two locations, a medium risk at four locations and a low risk at one location.

8.2.16 Construction compounds have the potential to interrupt surface water flow paths. Longhole viaduct compound (north) is located on the edge of a potential surface water flow path and although surface water flow may be slightly diverted, the overall flow path will not be altered and no vulnerable receptors would be at an increased

risk. At Cubbington retaining wall compound surface water flow paths are away from these temporary works and hence there will be no interruption of flow paths.

8.2.17 In line with the risk category matrix provided in Table 1, all other locations for temporary works within this study area are classed to be at no risk from surface water flooding.

8.2.18 The works will be completed in line with the CoCP and hence the design of the temporary works will prevent an unacceptable level of surface water flood risk on site.

8.2.19 Temporary works not identified to be at risk on the FMfSW also have the potential to increase flood risk from this source in neighbouring areas as a result of reduced ground permeability. Therefore, in line with the CoCP, surface water will be managed at all locations of temporary works, including areas not identified to be at risk from surface water in Table 9. This will ensure that the temporary works are at an acceptable level of risk and do not cause an increased risk elsewhere from surface water flooding.

8.3 Groundwater

8.3.1 Development may increase the risk of groundwater flooding where a structure is built across existing groundwater flow paths therefore altering the natural groundwater flow paths. The Proposed Scheme within this study area does not include any deep impermeable structures and therefore it is concluded that the Proposed Scheme is unlikely to significantly increase the risk of groundwater flooding.

8.3.2 There are three areas of below ground construction where temporary dewatering may be required. These areas are a cutting at Offchurch, a cutting and retained cutting at Cubbington and foundations for the viaduct over the River Leam. At these locations, the groundwater levels would need to be lowered by up to approximately 8m in the vicinity of the construction sites.

8.3.3 The CoCP will be adhered to and hence the Proposed Scheme will not result in an increased groundwater flood risk to the location of the works or in neighbouring areas.

8.4 Sewer systems

8.4.1 There are two locations where the route would cross sewer systems. However the risk to the Proposed Scheme from this source of flooding is low.

8.4.2 This is due to the location of the route in relation to inspection covers and that there are no known flow paths between surcharge points and the works. Once operational, it is not anticipated that the Proposed Scheme will impact on flood risk from this source. The most likely risk is considered to occur during the construction phase and the CoCP will ensure a minimal risk from this source.

8.4.3 The Proposed Scheme crosses the sewer network at one location. At this location the sewer network will be slightly realigned but will predominately follow the existing route. The other design elements at this location are earthworks and landscaping, and the only temporary works at this location comprise a temporary haul road. There are

no other design elements or temporary works known to be at risk from the sewer network in this study area.

8.4.4 The works will be completed in line with the CoCP and hence will ensure that the Proposed Scheme and neighbouring areas will not be at an increased flood risk from this source. One such measure outlined in the draft CoCP requires the removal or stopping and sealing of drains and sewers taken out of use. Similarly as outlined in the CoCP, precautions will also be taken to prevent damage to services and to avoid pollution during service diversions, excavations and ground penetration.

8.5 Artificial sources

8.5.1 At locations where the route crosses canals or areas at risk of flooding as a result of reservoir failure, there is potential that the Proposed Scheme may either increase the risk of flooding from this source, or divert flood water causing new areas to be put at risk.

Reservoirs

8.5.2 The areas at risk of flooding should Draycote Water, a designated reservoir, fail are located along the River Leam (map WR-01-028, D5, Volume 5: Map Book – Water Resources and Flood Risk). It is considered that the vertical clearance required for river flooding on the River Leam would be sufficient to prevent significant alteration of flood water flow paths and inundation during reservoir flooding. In addition Draycote Water is situated in excess of 10km upstream of the Proposed Scheme and hence the flood water, following a reservoir breach, would be at low velocity when it reaches the Proposed Scheme. Low velocity flood water is likely to cause less damage and pose a lower risk to life.

8.5.3 The reservoir inundation maps at this location indicated that the other design elements at risk of flooding from this source are earthworks and landscaping. Given that these earthworks were included in the hydraulic modelling (which showed minor impact on river flood levels) and that the reservoir inundation maps cover a similar extent to the river flood maps at this location, it is considered that these associated works would have a minor impact on reservoir flood paths.

8.5.4 The temporary works located in the area at risk of reservoir inundation include the redirection of a water main, a temporary haul road and associated watercourse crossing, and temporary fencing.

8.5.5 Due to the strict regulations and high maintenance associated with reservoirs the risks associated with flooding from reservoirs is low. Therefore the flood risk to all elements of the Proposed Scheme from reservoir failure is considered to be low.

8.5.6 The CoCP outlines that areas at risk of flooding should be considered when planning sites and storing materials. Although the flood risk areas are likely to be taken from the river flood risk maps WR-05-044b to WR-05-046b and WR-06-044b to WR-06-046b (Volume 5: Map Book – Water Resources and Flood Risk), at the location at risk from reservoir inundation in this study area the reservoir inundation maps broadly follow the river risk areas. Therefore it is considered that the temporary works will not significantly alter flood flow paths and hence not alter flood risk from this source to other receptors.

Canals

8.5.7 The Proposed Scheme will cross the Grand Union Canal at one location as shown on map WR-01-028, H6 (Volume 5: Map Book – Water Resources and Flood Risk). The crossing requires a minimum soffit height for navigational purposes and this soffit would be sufficiently high to prevent any impact on flow.

8.5.8 The other design elements of the Proposed Scheme at this location are landscaping and earthworks. As outlined in section 6.6, at the location of the crossing the canal is not fully raised although embankments are present potentially impounding water during periods of high water level. Therefore if structural breaching occurs, during periods of high water level, flooding may occur. However water levels in canals are highly maintained and thus overtopping or failure is considered unlikely.

8.5.9 The temporary works in the areas that would be at risk of canal flooding are North Bank worksite, plant and material storage and temporary fencing.

8.5.10 In line with the risk category matrix in Table 1, the risk to the other design elements and the temporary works is low. These works will be completed in line with the CoCP and hence will not impact on flood risk from this source.

8.6 Summary

8.6.1 The Proposed Scheme, including the route, other design elements and the temporary works will be located in areas at a very high risk of flooding from rivers. The design will ensure that the track is located above the 1 in 1000 (0.1%) annual probability flood event, with a freeboard, and hence will be at an acceptable level of risk. The other design elements and temporary works will be completed in line with design criteria and CoCP requirements and hence will also be at an acceptable level of risk. The hydraulic modelling completed for this assessment has shown that the Proposed Scheme will have a minor impact on flood risk. However the design will include mitigation to reduce this to a negligible impact.

8.6.2 All elements of the Proposed Scheme will cross many areas susceptible to surface water flooding. In general, at each of the areas the risk ranges from low to high, although as a conservative approach the highest level of risk has been assigned resulting in many of the areas being categorised as being at a high risk from surface water flooding. However the Proposed Scheme will mitigate surface water run-off to ensure that the works are at an acceptable level of flood risk and do not result in an increased risk elsewhere.

8.6.3 All elements of the Proposed Scheme have been categorised as being at a low risk from groundwater flooding.

8.6.4 All elements of the Proposed Scheme have been categorised as being at a low risk from the sewer network as there are no known flow paths between these sources of flood risk and the works. In addition, the works will be completed in line with the CoCP and hence will prevent an increase in flood risk from this source.

8.6.5 Water levels within canals are continually maintained and hence the chance of overtopping and thus flood risk from this source is considered low. Similarly, due to the strict monitoring and maintenance requirements, the risk of reservoir flooding to

the development is considered low. The design ensures that the Proposed Scheme does not result in an increased risk from this source both to the development and elsewhere.

9 Conclusion

9.1.1 The Proposed Scheme, including the route, other design elements and the temporary works, are to be located within areas at risk from flooding from a range of sources. However the temporary works will be designed to and will follow the CoCP such that development will be at an acceptable level of risk and will not cause an increased risk elsewhere. The proposed mitigation as part of the permanent works will also ensure that the Proposed Scheme will be at an acceptable level of flood risk and will not result in an increased risk elsewhere.

9.1.2 The magnitude of impact and significance of effects have been based on the EIA Scope and Methodology Report (SMR), see Volume 5: Appendix CT-001-00/1. Table 10 shows a summary of the sources of flood risk within this study area and the associated magnitude of impact and significance of effects.

9.1.3 In terms of river flooding, whilst the Proposed Scheme shows minor changes in flood risk, further design and mitigation will reduce this impact. Therefore taking this into account, the overall magnitude of impact in this study area is negligible and significance of effects neutral in terms of river flooding.

9.1.4 Although there are areas of the Proposed Scheme at no, low, medium and high risk from surface water flooding, overall the risk from this source is categorised as high, as a conservative approach. However the overall magnitude of impact is negligible and the significance is neutral. This has been determined because the design of the permanent works will be in line with the design criteria outlined in Section 0 of this report and the temporary and construction works assessed as part of this FRA are in line with the draft CoCP.

9.1.5 Groundwater flood risk is assessed as low.

9.1.6 The risk from sewer flooding is low within this study area, and the overall magnitude is negligible with a neutral significance. This has been determined because the design of the permanent works will be in line with the design criteria outlined in Section 0 of this report and the temporary and construction works assessed as part of this FRA are in line with the draft CoCP.

9.1.7 In this study area artificial sources of flooding (both from reservoir failure and canals) have also been categorised as low, resulting in a low significance of effect.

Table 10 Summary of flood risk receptors showing the overall magnitude of impact and significance of effects

Flood risk receptor	Risk category	Magnitude of impact	Significance of effects
Areas at risk from river flooding	Very High	Negligible	Neutral
Areas at risk from surface water flooding	High	Negligible	Neutral
Areas at risk from Groundwater Flooding	Low	Negligible	Neutral
Areas at risk from drainage and sewer flooding	Low	Negligible	Neutral
Areas at risk of flooding from artificial sources	Low	Negligible	Neutral

9.2 Residual flood risk to the Proposed Scheme

9.2.1 Residual flood risks arise in situations that are not included in standard design scenarios, for example when a culvert becomes blocked causing flooding upstream. All design is generally undertaken assuming that existing infrastructure is functioning under normal conditions. Consequently, there may be areas where the potential severity of flooding may exceed the design standard under certain circumstances.

Residual flood risks from river sources

Longhole viaduct

9.2.2 There are two existing hydraulic structures in the vicinity of Longhole viaduct, the Welsh Road Bridge and Longhole Bridge. Welsh Road Bridge is located upstream of the Proposed Scheme and therefore blockage at this structure will not lead to any significant increase in the risk of flooding to the Proposed Scheme. Depending on the constriction on flow caused by Welsh Road Bridge, any collapse of the structure could potentially cause a minor increase in flood levels at the location of the Proposed Scheme.

9.2.3 Longhole Bridge is located immediately downstream of the Proposed Scheme and there is the potential that blockage at this structure would impact on flood levels at the location of the Proposed Scheme. However the viaduct would be at a significant height above the floodplain, and hence the residual risks of flooding over and above the design event, and the risk of blockage, would not be significant.

Ash Beds culvert

9.2.4 All culverts within the Proposed Scheme are designed with a minimum internal headroom of 300mm above the design flood water level to minimise the risk of blockage. Therefore, there are not expected to be any significant increases in risk of flooding at minor watercourse crossings arising from potential blockage of culverts.

River Leam viaduct

9.2.5 There are no significant hydraulic structures within the vicinity of the Proposed Scheme that would create additional residual risks to the Proposed Scheme. The viaduct would be at a significant height above the floodplain, and hence the residual risks of flooding over and above the design event, and the risk of blockage, would not be significant.

Residual flood risks from surface water sources and minor watercourses

9.2.6 All culverts within the Proposed Scheme are designed with a minimum internal headroom of 300mm above the design flood water level to minimise the risk of blockage. Therefore, there are not expected to be any significant increases in risk of flooding at dry valley crossings arising from potential blockage of culverts. Inverted siphons have been used as a last resort for conveying flow beneath the Proposed Scheme and accommodation structures, where all other alternatives have been deemed unfeasible. Inverted siphons are prone to blockage and require regular maintenance. There is a residual risk of flooding in the event of siphons blocking.

Residual flood risks from groundwater

9.2.7 Groundwater levels rise and fall relatively slowly, and therefore any change in the risk of flooding from this source would be the result of below ground intervention. The risk of groundwater flooding already considered in this FRA presents an absolute risk, and there are no significant residual risks arising from this source.

Residual flood risks from the sewer network

9.2.8 Blockage of underground sewer networks can cause surcharge and associated flooding. At locations where the existing sewer infrastructure will need diverting, any replacement infrastructure would be to at least the same standard as existing. Consequently, no additional residual risk to the Proposed Scheme would be expected as a result of drainage system failure.

Residual flood risks from artificial and surface sources

9.2.9 This assessment considers the potential for total failure of Draycote Reservoir and the Grand Union Canal, which is deemed to be the most extreme case of flooding from these sources. Therefore it is considered that there are no further residual risks from artificial sources of flood risk.

9.3 Residual effects of the Proposed Scheme on flood risk

9.3.1 All culverts within the Proposed Scheme will be designed to convey the 1 in 100 (1%) annual probability flow including an allowance for climate change with a minimum internal headroom of 300mm above the design flood water level (to minimise the risk of blockage). Consequently, there would be negligible increase in upstream residual flood risks arising from the introduction of culverts within the Proposed Scheme.

9.3.2 All viaducts within the Proposed Scheme will also be designed so that the 1 in 100 (1%) annual probability flow with an allowance for climate change can pass underneath. As a minimum the design will ensure a 600mm freeboard will be provided to the bridge soffits above this level, and on main rivers where possible, a freeboard of 1m will be allowed. These freeboards will allow for debris and hence prevent a significant increased in residual risk in upstream areas as a result of the Proposed Scheme.

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